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ANTI MICRO-SHRINKAGE CAVITY INOCULATING ALLOY FOR THE TREATMENT OF CAST IRON

Domain of the invention

The invention relates to the treatment of liquid cast iron for manufacturing parts for which it is required to obtain a structure with no iron carbides and no micro-shrinkage cavities.

State of the art

Cast iron is a well-known iron-carbon-silicon alloy widely used for manufacturing of mechanical parts. It is known that to obtain good mechanical properties of these parts, it is important to eventually obtain an iron + graphite structure, minimising the formation of Fe_3C type iron carbides that make the alloy hard and brittle.

It may be desirable for the graphite formed to be spheroidal, vermiform or lamellar, but the essential prior condition to be satisfied is to avoid the formation of iron carbide. To achieve this, the liquid cast iron is subjected to an inoculation treatment before casting, that facilitates the appearance of graphite rather than iron carbide during cooling.

Therefore the inoculation treatment is very important. It is well known that the efficiency of inoculation on liquid cast iron reduces with time, regardless of the inoculants used, and the efficiency has generally dropped by 50% after about 10 minutes; an expert in the subject refers to this phenomenon as the

"fading effect". To achieve maximum efficiency, progressive inoculation is usually performed consisting of making several additions of inoculants at different stages of production of the cast iron. Thus, liquid cast iron is frequently inoculated, firstly in the ladle using an inoculating alloy, for example made of grains with a size of between 2 and 10 mm or between 0.4 and 2 mm, and secondly "by jet", in other words when the ladle is being poured using an inoculating alloy with grain sizes of between 0.2 and 0.7 mm, and finally "in the mould", in fact in mould supply ducts, by using inserts composed of an inoculating material along the path followed by the liquid cast iron.

These inserts with a defined shape are called slugs. There are two types of slugs:

- "cast" slugs obtained by casting a molten inoculant,
- agglomerated slugs obtained from a compacted powder usually with a very small quantity of binder or possibly without any binder at all.

An expert in the subject considers that cast slugs have the best quality; however, agglomerated slugs are often preferred for cost reasons. Since the casting time of a part is very short, the dissolution kinetics of the slugs must be very fast.

Moreover, an expert in the subject very frequently observes voids in parts with dimensions measured in millimetres or micrometers, referred to as micro-shrinkage cavities. These defects make parts more

brittle; moreover, if the parts have to be machined afterwards, for example to straighten a surface, the presence of such a defect on the surface will inevitably make it necessary to scrap the defective parts.

One known means of preventing the appearance of micro-shrinkage cavities in cast iron parts is to add lanthanum into the liquid iron. This metal in the lanthanum groups has the property of reducing the viscosity of the iron, not only of liquid iron just before the beginning of its solidification, but also during solidification, in other words the solid + liquid mix. Everything happens as if adding lanthanum makes the cast iron become thixotropic. Thus an expert in the subject, if he designs the moulds correctly, can collect all the shrinkage cavities in the feeder head and thus obtain sound parts.

Thus, nodulising agents containing lanthanum have been successfully marketed, and are reserved for use in nodular cast irons called SG cast irons, and FeSi type inoculants with 45% Si and 2% La have also been marketed, that can be used equally well for SG cast irons and for lamellar graphite cast irons, called LG cast irons.

The purpose of the invention is to provide inoculating alloys that can be used to treat liquid cast iron enabling efficient inoculation, particularly during treatment "in the mould", preventing the formation of micro-pores in parts obtained by casting.

Object of the invention

The object of the invention is inoculating alloys that will be used for the treatment of cast iron containing (by weight) 0.005 to 3% of an element in the bismuth, lead and antimony group, 0.3 to 10% of metals in the group consisting of rare earths and possibly up to 5% of aluminium and up to 1.5% of calcium, the remainder being ferro-silicon, lanthanum accounting for more than 90% of the rare earths metals used in its composition.

The alloy preferably contains between 0.2 and 1.5% of bismuth, and preferably between 0.7 and 1.3%. The content of lanthanum is advantageously between 0.3 and 8%, and preferably between 0.5 and 3%. The presence of at least 0.8% of aluminium is advantageous, and its content is preferably between 1 and 3.5%.

The alloy according to the invention may be conditioned in the form of a powder or a mix of alloy powders with different compositions, or in the form of slugs moulded from the molten alloy, or agglomerated from a powder or a mix of powders. This powder preferably has a grain size smaller than 1 mm, with a size grading fraction between 50 and 250 μm accounting for more than 35% of the total weight, and a fraction smaller than 50 μm representing less than 25% of the total.

Description of the invention

Since an inoculant is inherently intended to obtain cast iron with carbon present in the form of graphite, the applicant thought that it would be desirable to

develop an inoculant with anti micro-shrinkage cavity properties.

Thus, the first step was to envisage inoculating alloys based on 75% FeSi with an added anti micro-shrinkage cavity element that could be lanthanum or germanium. Required contents of germanium vary from 0.3 to 6%. Required contents of lanthanum vary from 0.3 to 8%, and preferably from 0.5 to 5%.

But more attractive solutions appeared by imagining inoculating alloys in which the same element could fulfil several functions: thus, it was found to be particularly attractive to start from an alloy like that described in US patent 4432793 (Nobel-Bozel) based on ferro-silicon and containing up to 3% of bismuth, lead or antimony, and up to 3% of rare earths, adding an anti-micro-porosity element to it such as lanthanum, and contracting the formula obtained by optimising the total amount of lanthanum and other rare earths in the Fe-Si-Bi-La alloy.

The applicant started by checking that these new anti-micro-porosity alloys conditioned in normal size gradings, namely between 2 and 7 mm, or between 0.4 and 2 mm for treatment in ladles, and between 0.4 and 0.7 mm for treatment in jets, had good properties as inoculants. The next step was to envisage the preparation of inoculating slugs with these same alloys. The result in terms of reduction of the micro-porosity was confirmed by the added bismuth in the final cast iron.

Thus, very good results were obtained with cast slugs composed of an FeSi type alloy containing:

- from 60 to 80%, and preferably from 72 to 78% of silicon,
- from 0.3 to 8%, and preferably from 0.5 to 5% of lanthanum,
- from 0.2 to 1.5%, and preferably from 0.7 to 1.3% of bismuth,
- from 0.8 to 5% and preferably from 1% to 3.5% of aluminium.

Examples

The examples described below were made by melting a cast iron charge in an induction furnace and treated using the Tundish Cover process using a normal FeSiMg type inoculating alloy with 5% of Mg and 1% of Ca not containing rare earths, using the dose of 20 kg for 1600 kg of cast iron. The analysis of the liquid cast iron was as follows:

C = 3.7%, Si = 2.6%, Mn = 0.07%, P = 0.03%, S = 0.003%, Mg = 0.038%.

The performance in terms of macro-porosity and micro-porosity was evaluated using the "V" test pieces casting test.

In this test, the test piece is composed of a 110 mm high "V" with an angle at the vertex equal to 40°C, the width of the branches of the "V" being 20 mm and the thickness of the part being 20 mm. This geometry results in a width of 80 mm at the vertex of the "V", a unit volume of 69 cm^3, and a unit mass of 480 g to 500 g depending on the quality of the cast iron. Pores in this

type of part appear selectively in the re-entrant part of the "V".

To evaluate the test result, the part is cut at mid-thickness, and the section is examined by optical microscopy to evaluate the pore surface; the result is expressed as a surface area of pores as a fraction of the surface area of the section.

Example 1

A treated cast iron ladle originating from the preliminary operation was inoculated in the ladle using a powder inoculating alloy with a size grading between 2 and 10 mm, with a "Foundry Grade" composition, the remainder being mainly Fe, used at a dose of 200 g per tonne of cast iron.

This cast iron was used to cast V parts with geometry identical to that defined in the control test, arranged in clusters in a 36-part sand mould supplied by an inlet duct in which there is a filter composed of a refractory foam.

The parts obtained were examined by optical microscopy on a polished section to determine the metal structure as a function of the porosity depth and level.

The density of graphite modules at the heart of the branches was measured at $120/mm^2$.

The average porosity of the parts was evaluated at 2.4%.

Example 2

A second treated cast iron ladle from the preliminary operation was inoculated in the ladle using an inoculating alloy with a size grading of between 2 and 10 mm of composition:

Si = 75.4%, Al = 0.94%, Ca = 0.86%, La = 2.2%, Bi = 0.92%, remainder mainly Fe, used at a dose of 200 g per tonne of cast iron.

This iron was used to cast V parts with geometry identical to that defined in the control test, arranged in clusters in a 36-part sand mould supplied by an inlet duct in which there is a filter composed of a refractory foam.

The parts obtained were examined by optical microscopy on a polished section to determine the metal structure as a function of the porosity depth and level. The density of graphite modules at the heart of the branches was measured at 360/mm^2.

The average porosity of the parts was evaluated at 0.3%.

Example 3

A third treated cast iron ladle originating from the preliminary operation was used to cast V parts with geometry identical to that defined in the control test, arranged in clusters in a 36-part sand mould supplied by an inlet duct in which 25 g slug is located composed of an inoculating alloy for treatment in the mould, with composition:

Si = 73.6%, Al = 3.92%, Ca = 0.78%, La = 2.1%, Bi = 0.97%, remainder mainly Fe. The parts obtained were examined by optical microscopy on a polished section to determine the metal structure as a function of the porosity depth and level. The density of graphite modules at the heart of the branches was measured at 320/mm^2.

The average porosity of the parts was evaluated at 0.2%.